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A Reappraisal of How Oral Rehydration Therapy Affected Mortality in Egypt

Hoda Rashad

Do not expect too much from oral rehydration therapy. An upper ceiling for the potential impact of oral rehydration therapy in Egypt is a 25 percent reduction in the infant mortality rate.

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Oral rehydration therapy is the key low-cost child survival intervention used to deal with diarrheal illness in developing countries. The existence of a low-cost, highly efficacious technological fix (oral rehydration salts) for the life-threatening dehydration that accompanies diarrhea provided a strong rationale for making oral rehydration therapy a cornerstone of diarrheal disease control programs. The Egyptian oral rehydration therapy program has been quoted as having the most spectacular success in reducing infant and child mortality. But there is a need to differentiate between the efficacy of oral rehydration therapy in clinical settings and in community use.

The National Control of Diarrheal Diseases Project (NCDDP) was launched in Egypt in 1983. A pilot program was followed by national promotion starting in February 1984. As early as 1985, opinions were being expressed about the favorable impact of NCDDP activities on child mortality.

There is no doubt that the NCDDP greatly increased both awareness of the dangers of dehydration consequent upon diarrhea in children and knowledge of oral rehydration therapy. But survey data on the use of oral rehydration therapy during diarrheal episodes show such use to be far from universal (with use in fewer than 50 percent of episodes). Further, ethnographic studies show appropriate use, in terms of timing and quantity, to be the exception rather than the rule.

The maximum theoretical effect of the NCDDP on child mortality would be to eliminate all deaths from diarrhea, a reduction of about 50 percent. The maximum effect that could realistically be expected is a reduction of less than 20 percent. Analysis of a time series of infant mortality from vital registration data indicates an abrupt, statistically-significant change in level in 1985 amounting to a once-off decline of about 15 percent. In the absence of other changes taking place at about the right time that might explain this drop, it is concluded that the NCDDP probably was responsible. Thus, although many of the claims made for the impact of the NCDDP on child mortality in Egypt appear to have been greatly exaggerated, it does seem likely, in the absence of alternative explanations, that the program significantly reduced infant mortality in the mid-1980s.

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INTRODUCTION

Oral rehydration therapy (ORT) is the key low cost health intervention included in primary health care packages in many developing countries to deal with their high toll of diarrheal morbidity. The existence of a low cost, highly efficacious technological fix (oral rehydration salts) for dehydration consequent upon diarrhea provided a strong rationale for making ORT a cornerstone of diarrheal disease control programs. The large scale implementation of this therapy in different communities highlighted the need to differentiate between the efficacy of an intervention in clinical settings and its effectiveness in actual applications.[1,2]

The importance of the socio-political, cultural and economic barriers to reaching the full potential of this treatment suggests that the impact of such therapy is less than initially envisaged. However, very few studies have actually examined the mortality impact of ORT interventions in large community settings[3-8]. The Egyptian ORT program appears to provide the strongest support for the significant role played by ORT in reducing infant and child mortality and is quoted as having the most spectacular success[9].

The success or otherwise of the Egyptian program has important implications for the strategy of health improvements, not just within Egypt but also for other developing countries. Thus, it is crucial to examine the evidence that has been presented in support of a causal link between the program and declines in infant and child mortality, and to decide whether it is adequate for such an important inference. This paper attempts to reappraise the previous evaluation attempts through making use of new sets of information and following closely the basic steps for impact evaluations.

REVIEW OF THE EGYPTIAN PROGRAM AND PREVIOUS STUDIES

The National Control of Diarrheal Diseases Project (NCDDP) was launched in Egypt in 1983. In its first year efforts were concentrated in only one of the country's 26 governorates. This pilot program was followed by national promotion starting in February 1984. The NCDDP's aim was to increase the use of oral rehydration therapy (ORT) in episodes of diarrhea. The program activities covered training of health workers, national production of oral rehydration salts, establishment of special medical units for treatment of diarrheal disease, and conduct of a large media campaign. The objectives of this media campaign were to increase knowledge of dehydration signs and of the use of oral rehydration salts to treat dehydration, and to change certain behaviors, such as stimulating use of ORS at the onset of diarrheal attacks and continuing breastfeeding during episodes.

NCDDP had been preceded by other activities. The Ministry of Health introduced a national program for provision of ORT through its clinics in September 1977. In spite of possible small contributions, the general consensus is that prior to 1984, no marked changes occurred in either utilization of ORS or the outcome measure of mortality.[5, 6, 7]

Two controlled field trials[10] of oral rehydration therapy in rural villages of two governorates in Lower Egypt (Menoufia, Dakahlia) were conducted around 1980. The impact of each of these trials was evaluated. The two evaluations reported dramatically different findings. The Menoufia study concluded that the ORT intervention efforts did not reduce diarrheal mortality among children. The Dakahlia study indicated around 50 percent less diarrheal mortality and 40 percent less overall mortality among children aged one month to five years for certain configurations of program interventions. Tekce (1982)[7] suggested that the difference in results could have been due to different intervention strategies. The Dakahlia trial had better elements (for example, periodic home visits, health personnel education, more reliance on nurses with higher credibility among mothers) than the Menoufia trial. These elements may have achieved fuller cooperation as well as provided better support for the mothers in utilizing the new therapy. The importance of these two impact studies for the national evaluation attempted here is that they provide needed baseline information (prior to NCDDP) on the clinical epidemiology and management of diarrheal episodes. Another source of information is a diarrhea surveillance study[11] in children under 3 years of age conducted in 6 sentinel communities.

As early as 1985[12], opinions were being expressed on the positive demographic impact of NCDDP activities. However, some observers were questioning the validity of conclusions drawn about causality. A detailed review was performed of the available sets of data[13], concluding that the causality statements required firmer substantiation. Major concerns of the study were the reliability of the available data and their inadequacy for supporting more positive statements of impact.

Making use of more up to date information, several recent studies[5, 6] have attributed a substantial portion of recent child mortality declines in Egypt to ORT activities. The basic rationale of, and pieces of evidence presented in, these studies are summarized below. The studies start by presuming that the successful application of ORT would result in a significant reduction in child mortality. This presumption rested upon three considerations. First, at least half of the infant and child deaths in Egypt prior to the 1980s were diarrhea-associated. This figure is supported by the civil registration statistics summarized in Table 1. Second, prior to the project, there was poor case management of diarrheal episodes. Third, the theoretical efficacy of ORS was well established.

The studies provide ample evidence that basic project input goals such as production and accessibility of oral rehydration salts, training of physicians and annual public education campaigns via the media were satisfied. Concerning the actual outputs of the project, the studies refer to greater knowledge of ORT and of the dangers of diarrheal episodes. They also report that the required changes in the management of acute diarrhea had occurred. The evidence on which such statements were based is summarized in Table 2, which is derived from three publications[5, 6, 14]. The data are drawn from three sets of studies. The first is a series of national Knowledge, Attitude and Practice (KAP) surveys commissioned by NCDDP and conducted annually since 1984. The study universe covered Cairo and eight other governorates (four in Lower Egypt and four in Upper Egypt). The other two studies are a 1986 follow-up of the Dakahlia 1980 control study and a 1988 follow-up of the Menoufia 1979-80 control study.

Table 1. Proportion of diarrheal associated deaths to all infant deaths and to post-neo infant deaths (1965-1988)

YEAR	PROPORTION OF DIARRHEAL ASSOCIATED DEATHS	
	TO ALL DEATHS 0-11 MONTHS	TO DEATH 1-11 MONTHS
1965	52.79	62.85
1966	55.12	65.05
1967	55.65	66.15
1968	58.21	67.30
1969	61.25	71.35
1970	48.91	56.90
1971	40.51	47.18
1972	45.82	52.24
1973	49.22	56.88
1974	52.44	59.89
1975	48.37	55.41
1976	52.98	60.66
1977	50.81	57.37
1978	51.88	59.36
1979	52.49	59.38
1980	51.56	60.17
1981	51.24	58.79
1982	47.06	55.93
1983	45.35	52.14
1984	41.81	48.51
1985	36.92	44.24
1986	33.95	42.75
1987	32.53	40.86
1988	28.77	36.66

Source: Annual Vital Statistics Reports published by Central Agency for Public Mobilization and Statistics, Egypt.

The inference concerning a causal connection between the program and reduced child mortality was based on the sharp decrease in infant and childhood mortality, particularly diarrhea-associated mortality, that followed the ORT intervention. Table 3 summarizes the evidence presented.

Before accepting the evidence of a change in diarrhea-associated mortality, it is necessary to make sure that the decline in diarrheal mortality is a true change rather than a change in the tendency to misclassify cause of death. Such a change in misclassification could result from the program itself, as a result of the extra attention and the large media campaign focussed on diarrhea. Seasonal trends, which do not have the same potential for misclassification, were used as an alternative indicator of trends in cause of death. The reduction in the proportion of deaths occurring in the summer season (the high season of diarrhea) from around 45% prior to 1983 to around 33% in 1987 was used as an indicator of true changes in diarrheal deaths. Another test for bias arising from misclassification of cause of death was performed by checking whether the decrease in the number of diarrhea-associated deaths had been offset by an increase in the number of deaths from other causes, either from replacement mortality or classification bias. No offsetting effect was detected in the data.

Accepting a substantial change in mortality, the investigators dismissed the contributions of factors other than NCDDP to this change by noting "the immediate determinants of diarrheal mortality may be classified as curative care, incidence, and host resistance; other factors must operate through one or more of these determinants. There was no major change in the incidence of diarrhea or nutritional status during the course of the project. We cannot exclude changes in the severity of illness (eg, subtle changes in the virulence of microbes causing diarrhea) but ORT together with continued feeding reduces duration of diarrhea".[5]

Table 2. Summary of evidence in studies supporting positive impact of NCDDP

	before NCDDP (most around 1980)	84	85	86	87	88
% ever used ORS						
National Data (b)	27 (a)	50	64	68	66	
Menoufia (c)						80
% of mothers who can mix correctly						
National Data (b)	12 (d)	53	73	81	88	
Menoufia (c)						86
Dakahlia (e)				90		
% use of ORT in last episode						
Menoufia (c)	39 (f)					52
Dakahlia (e)				81		
% of children being breastfed, with breastfeeding continuing through episode						
National Data (b)	42 (g)	68	83	86	83	
Menoufia (c)						93
Dakahlia (e)				72		

Source: references: 5, 6, 14

a. Dakahlia control group (n=105)
b. NCDDP commissioned KAP household cluster survey (n=1,500)
c. Menoufia follow-up study 1988
d. Dakahlia control group (n=410)
e. first round Dakahlia follow up study (control and outreach)
f. first round Dakahlia 1980 study (control and outreach)
g. 3 surveys in Menoufia governorate, pooled (n=1,062 episodes)

Table 3. Infant and Childhood Mortality, 1970-1987

	INFANT MORTALITY*		CHILDHOOD MORTALITY	
YEAR	DIARRHEAL	OTHER	DIARRHEAL	OTHER
1970	65.9	50.0	17.0	15.2
1971	48.6	54.4	11.6	15.4
1972	60.8	55.6	14.4	16.4
1973	55.8	42.2	11.6	12.0
1974	59.6	41.4	11.8	10.0
1975	49.3	39.7	10.3	11.2
1976	52.8	34.2	9.6	8.5
1977	49.0	36.3	9.7	9.1
DECLINE 1970-77:	4.2	4.6	8.0	7.3
1978	43.7	29.8	6.7	6.3
1979	42.3	34.1	9.5	7.6
1980	39.2	36.8	5.7	5.5
1981	36.0	34.3	4.9	6.3
1982	33.2	37.3	5.9	7.7
DECLINE 1977-82:	7.8	-0.5	9.9	3.3
1983	29.1	35.6	4.0	6.0
1984	25.8	36.3	4.0	6.4
1985	15.3	33.9	2.7	6.9
1986	15.2	32.0	2.6	5.2
1987	12.3	32.8	2.3	5.5
DECLINE 1982-87:	19.9	2.6	18.8	6.7

Source: Figures in table (3) for 1982 to 1987 were based on detailed tabulations prepared specially for NCDDP by the civil registration authority.

* Figures reported here are different from the ones reported in table 6, particularly for 1985 and 1987. Table (6) used the published official data not the special tabulations. The difference can be explained as follows: Diarrheal rates in table (3) excluded some diseases of digestive system. The official reports that are the basis of table (6) included these diseases and excluded Cholera and Typhoid fever. The difference in infant mortality rate for 1987 resulted from using preliminary data which seem to have included births occurring to Egyptians abroad in the denominator of table (3).

EXAMINATION OF EVIDENCE

The basic steps of the impact evaluations examined in this study are the specification of a conceptual framework, the actual implementation of the project and the attribution of causality. The present analysis emphasizes the importance of the first two steps (conceptualization, implementation) of impact evaluation. It turns out that both the anticipation of a large decline in mortality as a result of ORT use and the statements concerning proper management of episodes were based on very weak information. The paper then presents a new analysis of changing mortality trends using a regression discontinuity analysis which avoids biased inferences due to choices of specific starting or ending years.

1- Conceptualization

Conceptualization refers to a spelling out of causal mechanisms. Specifying in detail the course of actions through which program activities lead to envisaged effects is important because it allows a sound choice of suitable outcome measures and plausible theoretical quantification of potential impact.

In general, ORT (with all its elements of ORS, nutrition and hygienic practices) has the potential for reducing case fatality of acute watery diarrhea (ORS and nutrition provides replacement of fluid and electrolytes to combat dehydration). The therapy reduces case fatality of all types of diarrhea and indeed of other diseases also (through its effect on nutritional status that in turn influences host resistance) and even reduces the incidence rates of diseases (improved nutritional status alters immuno-competence and better hygienic practices reduce exposure risks).

In the Egyptian program, the early messages focused on ORS and the evidence that has been cited suggests no change in either nutritional status or incidence rates. Thus, one route of impact is specified: The reduction of case fatality of acute watery diarrhea due to better palliative case management of episodes. The proper outcome variable is deaths due to dehydration and the theoretical quantification is strongly related to that.

The first step in the analysis examines the possible theoretical impact of eradicating all dehydration deaths in Egypt. Two points need to be considered:

- Cause of death statistics in Egypt are known to be inaccurate. The 50 % level of diarrhea associated deaths may be too high. This in itself may be overstating the potential impact of the ORT program.

- Dehydration deaths represent only some proportion of all diarrhea associated deaths. There is a need to quantify this proportion better to avoid another possible source of overestimation of potential impact.

To discuss these two points, we need better information on the cause of death structure in Egypt and an estimate of what proportion dehydration deaths are of all diarrheal deaths. The objective here is to reach a plausible estimate of dehydration mortality in Egypt, which in turn will set the upper ceiling of maximum possible impact of the program.

It is unfortunate that detailed base line epidemiological studies are not available for Egypt. Most of the available evidence comes from a few small area studies. A study[11] of diarrheal morbidity (but not mortality) conducted around 1983 in several Egyptian communities suggests a high toll of such morbidity. On average, young children were found to have diarrhea for 11 percent of the time (varying from 13 percent in the under ones to about seven percent in the 2 to 3 year olds), and nearly two-thirds of this diarrhea was watery. The 1980 Menoufia controlled field trial[7] conducted careful retrospective medical interviews, discussions and consultations to determine the most probable primary cause of reported deaths. The data showed that diarrheal deaths constituted some 48% and 55% of infant and childhood deaths respectively. The scanty information available does not support the notion that diarrheal deaths are overstated in the civil registers.

Information on deaths due to dehydration are even more difficult to come by and little is known for Egypt. Black (1984)[15] states that acute diarrheal deaths usually constitute 50-60 percent of all diarrheal deaths. If this figure applies to Egypt, a potential impact of ORS is around 50% of diarrhea associated deaths and 25% of infant deaths. The few studies[16, 17] that have examined closely the contribution of acute watery diarrhea, the type most likely to respond to ORS, to overall mortality come up with much lower estimates. These studies are based on the Matlab field project in Bangladesh. They estimate that acute watery diarrhea deaths accounted for 11% of all deaths in 1 to 11 months old[16] and only 5.5% of all infant deaths[17].

The few and quite different estimates available for the share in mortality of dehydration deaths caused by episodes of acute watery diarrhea, and the fact that the role of ORS in preventing death from dysenteric or chronic diarrhea is limited, suggest the need for greater caution in estimating the potential of ORS.

Another point of concern is the role of ORS in influencing the health status of those cured from dehydration. Mosley and Becker[18] point out that children not dying from dehydration are more frail and more predisposed to further infection with increased risk of dying. This attenuates the mortality-reducing potential of curative interventions. Others maintain that ORS may reduce the severity and duration of subsequent sickness episodes through its role in limiting the nutritional damage during an acute watery diarrhea episode. No scientific evidence is available to support either claim.

2- Implementation

When examining the evidence presented in Table 2, there is a need to pay attention to the reliability and validity of the reported information. Some of the data may not be of high quality. Also, it is well known that the methodology adopted to obtain the specific pieces of data can have important implications for the validity of results. Further, Menoufia, in particular, had intensive presence of activities prior to the NCDDP - and it is likely that successes reported there cannot be used as a basis for national generalization. Bearing these caveats in mind, a closer look at the evidence presented in Table 2 is carried out below. The quality of information is not investigated here and all surveys are assumed to be of reasonable quality.

All evidence on ORT utilization before NCDDP is derived from the two control trials in small areas. It seems reasonable to assume that the data related to ORS practice would hold nationally. However, the percentage of ORT use prior to NCDDP may be inflated by the fact that the first round of the Dakahlia 1980 control trial started a few months after the ORT promotion activities. The data on continuation of feeding during episodes could have benefitted from other supportive evidence, but the case made for weak management of episodes seems reasonable. For the period after the initiation of the NCDDP, the percentage of ever use of ORS differs between the National (66%) and the Menoufia (80%) surveys, despite the fact that both surveys collected information concerning children less than 2 years of age. The difference in utilization may be attributed to the concentration of efforts in Menoufia that started before NCDDP. The evidence suggests that two out of three mothers (with young children) have at least once used ORS and that most women (over 85% of respondents) can mix it properly. The proper mixing was actually observed by interviewer.

To sum up, most available studies and reviews are in agreement that the NCDDP has succeeded in improving knowledge and general use of oral rehydration salts. The percentage of ORS use in recent episodes and the quality of such use are two key pieces of information for inferences about impact.

a) *ORS Use in Recent Episodes*

It is surprising to note that data on ORS use have not been presented on a national basis to support causality inference. A probable explanation is the fact that the reference periods of the last episodes in the national KAP studies (prior to 1988) were almost open ended. The question referred to the experience of diarrhea since the previous Ramadan (the month of fasting in Egypt which occurred several months before the survey). For each child experiencing diarrhea in the reference period, questions were asked about use of ORS in the most recent episode. The rate obtained from the 1988 national KAP for this rather long reference period is 51%, which is almost identical to the Menoufia rate of 52% (the Menoufia study suffers from the same problem of long reference period). It is strongly suspected that this methodology tends to overstate percentage utilization. The Dakahlia evidence refers to children under the age of five and the recall period was 2 weeks prior to the survey. The level of utilization reported (81%) is impressive and deserves a closer look to determine its validity for national inference.

In a critical assessment of the utilization of ORS use rates as an ORT program indicator, Larson and Mitra (1990) [19] refer to 4 national surveys taken in Bangladesh during the 1980's that gave use rates ranging from 14 to 80 percent. The authors discuss three methodological issues to which use rates are sensitive: "The terms used to describe a diarrheal episode, the reference period of the episode for which treatment information is collected and the prompting sequence regarding treatment". We add to these issues the type of diarrhea. Severe diarrhea episodes may have a higher use rate of ORS than milder ones. Thus in Egypt, data collected for younger children during the summer season are likely to show higher rates. To obtain more valid and consistent information on use rates, an attempt is made to reduce methodological biases by standardizing for reference period and age of children. Also, newer evidence is presented[20, 21, 22, 23, 24]. A summary of information is presented in Table 4. It is obvious that, even after standardization, a wide range of estimates of ORS use in last episodes is provided by different sources of data. In what follows, an attempt is made to reach a single plausible estimate.

The use rate provided by the Menoufia KAP survey is identical to the September/October use rate of the 1990/91 Menoufia Child Survival in Rural Egypt survey. Menoufia use rates are much higher than the national rates, though the difference is reduced by comparing Menoufia to Lower Egypt. The higher use rates for Menoufia may be explained by one or more of the following: the two week reference period may favor recollection of severe cases with higher than average utilization of ORS; and the special history of Menoufia[25] may have resulted in ORS utilization rates above the national average.

The expectation that the conduct of the Egypt Demographic and Health Survey (EDHS) in winter would underestimate the ORS use rate is not supported by data from Menoufia classified by survey dates, since these data show little variation in use rate per episode by season (see Table 4). The EDHS national estimate of utilization of around 30% seems the most reasonable, but to avoid any underestimate of utilization of ORS an average (using both EDHS and Menoufia Child Survival Survey) level of ORS utilization is around 42%, 44% and 37% for ages less than 1 year, 2 years and 5 years respectively.

The NCDDP encouraged use of ORS at the onset of diarrheal attacks. Nevertheless, the available evidence (unfortunately EDHS estimates are not available yet) strongly suggests differential treatments by type of episode, as is shown in Table 5. Allowing a ratio of 3:1 (a higher ratio than implied by actual data) for use of ORS in severe to non severe cases, and a distribution of diarrhea by mild and severe of 2:1, would provide an estimate of ORS utilization in severe cases of around 75%. This is of course a very rough estimate but it is as good as the available information permits.

We can now put an upper bound on impact. Assuming proper utilization and that half of all diarrheal deaths are due to dehydration (both quite generous assumptions), the maximum expected reduction in diarrhea associated mortality is 37.5% (.5 X .75) and in infant mortality 19% (.5 X .5 X .75).

b) *Quality of Use*

The anticipated reductions in diarrheal and overall infant mortality assume 100% efficacy of ORS. Efficacy of ORS is well established in clinical settings. In community settings, the social constraints that resulted in high incidence rates of diarrhea are the same constraints that are likely to impede the proper utilization of ORS.

Table 4. SUMMARY OF EVIDENCE ON USE OF ORS DURING LAST DIARRHEAL EPISODE BY RECALL PERIOD, AGE OF CHILD AND SEASON OF SURVEY

SURVEY	SEASON	YEAR	RECALL PERIOD					
			LAST WEEK			LAST 2 WEEKS		
			<1 YEAR	<2 YEARS	<5 YEARS	<1 YEAR	<2 YEARS	<5 YEARS
EDHS	WINTER	1988						
EGYPT			29.9	32.6	28.7			
LOWER EGYPT					36.0			
NATIONAL KAP	WINTER	1988		14.3			16.1	
MENOUFIA KAP	WINTER	1988					45.0	
MENOUFIA C.S.	ALL YEAR	1990				54.1	55.2	45.1
	JULY/AUG							40.1
	SEPT/OCT							45.9
	NOV/DEC							48.4

Source: The data are drawn from the first country report of Egypt Demographic Health Survey [24], a draft report[21] on the base line round of a Menoufia child survival study underway under Johns Hopkins / AUC auspices, and recent national and Menoufia KAP impact studies[22, 23] conducted by SPAAC in Egypt.

Table 5. Use of ORS(%) by type of diarrhea

"Severe" vs. "mild" diarrhea

	NATIONAL KAP 1988	MENOUFIA KAP 1988	MENOUFIA CS 1990
SEVERE	69.7	71.6	66.2
MILD	25.2	38.7	36.8
"Dehydrated" vs."not dehydrated"			
	MENOUFIA KAP 1988	MENOUFIA CS 1990	
DEHYDRATED	83.4	89.2	
NOT DEHYDRATED	32.8	32.7	

Source: references 22, 23, 21.

Ethnographic methods are clearly superior to cross-sectional surveys in reporting actual case management of diarrhea, as the latter may tend to obtain answers that reflect the ideal behavior supported by media messages. The results of an ethnographic study[26] conducted in 6 communities with 56 cases of diarrhea followed daily strongly suggest improper utilization of ORS. Such improper use would, in turn, greatly reduce the expected impact on both diarrhea associated and infant mortality.

3- Investigation of Causality

The two previous steps dealing with theoretical quantification and implementation analysis provide some sobering insights. The first relates to the complex mechanisms through which ORT may exert its impact on mortality. The simplest curative mechanism that is implied by the early focus of the program and data on incidence and nutritional status has a lower theoretical potential than that implied by the more complex mechanism passing through health status. The implementation data - particularly ORS utilization and quality of use - further reduces the expected demographic impact of ORT.

This section investigates mortality trends and attempts to answer the question: is the pace of change after 1984 significantly different from the pace of change prior to the project period? A regression discontinuity analysis is adopted[27]. This procedure examines time series data involving a one group pre test - post test design in which data are available for a number of times before and after program implementation. The trend in the series is examined as a function of time, which is used as a surrogate for other causal factors. A dummy variable is added to the model to capture post-project activities. Tests are performed to check whether the amount and speed of change in the outcome measure (following project activities) could have occurred by chance or are too large for this conclusion to be drawn. The advantage of adopting a regression methodology is in avoiding inferences shaped by particular choices of specific starting and ending dates for the series. However, the methodology does have pitfalls. First, there is an implicit assumption that the previously exhibited trend would have prevailed in the absence of NCDDP activities. This assumption can never be substantiated given the lack of controls and the complex interactive processes governing mortality change. Nevertheless, the assumption of continuation of prior trends seems the most reasonable one in the absence of information to the contrary. Second, a decision on significant deviations from prior trend is closely related to the type of models chosen for the fit. The assumption of a constant yearly magnitude of decline implied by the linear trend may be unsuitable for dealing with mortality change since improvements in mortality become more difficult to achieve with lower bases and relative declines gain more importance. However, the linear trend is justified by the almost perfect fit to the existing data, the short span of time considered and, more importantly, the fact that a significant linear change would imply a significant relative change with higher confidence. Significance will also depend on the selected starting point of the series and on the date from which a deviation in trend is expected.

The model is specified as:

$$y_i = a + b\,t_i + c\,p_i \qquad (1)$$

where y, the dependent variable, is the IMR or the post-neonatal mortality rate or the diarrhea associated post-neonatal mortality rate, t is time, with the starting year taken as equal to 1, and p is a dummy variable representing project activities, equal to 0 prior to the project and equal to 1 after project initiation. The parameter c measures the change in intercept following project activities. Standard methods are applied to test whether the parameter c is significantly different from zero, that is, to test whether the change in intercept could reasonably have happened by chance.

A second model can test for the possibility that the program might have changed the speed of decline in mortality (whether a change in intercept occurred or not). This hypothesis is investigated by introducing a time-project interaction into the model as follows:

$$y_i = a + b\,t_i + c\,p_i + d\,(t_i\,p_i) \qquad (2)$$

It is important for the analysis to choose an appropriate starting point for the time series, and also to choose an appropriate date, given program characteristics, from which a deviation in trend is expected (allowing a preliminary period for the project to reach its full potential). Table 6 and Figure 1 summarize relevant information on infant mortality and diarrhea associated mortality from which these choices can be made.

Registered IMR in Egypt portrays a picture of wide fluctuations up to the mid-seventies, after which a smoother, more systematic trend is established. It should be emphasized that these rates are believed to suffer from under-registration, but the available studies do not point to recent improvements in registration completeness. Adjusted rates for Egypt [28] portray trends similar to those of the registration data from 1970 onwards (but of course at a higher level). A starting date for the series of 1975 seems reasonable in view of the smaller erratic variations that occur thereafter, while at the same time providing a time series of adequate length. The NCDDP started nationally in 1984, but it seems reasonable to allow one year for the program to get underway before expecting effects. Figure 1 also suggests a break in the series in 1985. Thus 1985 is taken as the beginning of post project period, and p_i is set equal to zero up to 1984, and equal to one for 1985 onwards.

Table 6. Infant and diarrheal associated mortality*, yearly absolute and relative percentage change

YEAR	IMR	DIARRHEAL ASSOCIATED MORTALITY	ABSOLUTE CHANGE		PERCENTAGE CHANGE	
			IMR	DAM	IMR	DAM
1965	113.15	59.60				
1966	127.05	70.03	13.9	10.07	12.28	16.79
1967	116.09	64.60	-10.96	-5.43	-8.63	-7.75
1968	131.27	67.42	15.18	2.82	13.08	4.37
1969	114.60	70.20	-16.67	2.78	-12.70	4.12
1970	116.28	56.88	1.68	-13.32	1.47	-18.97
1971	103.27	41.83	-13.01	-15.05	-11.19	-26.46
1972	115.97	53.24	12.70	11.31	12.30	27.04
1973	97.96	48.21	-18.01	-4.93	-15.53	-9.28
1974	101.26	53.10	3.30	4.89	3.37	10.14
1975	89.17	43.13	-12.09	-9.97	-11.94	-18.78
1976	87.49	46.35	-1.68	3.22	-1.88	7.47
1977	85.29	43.33	-2.20	-3.02	-2.51	-6.52
1978	73.46	38.11	-11.83	-5.22	-13.87	-12.05
1979	76.43	40.12	2.97	2.01	4.04	5.27
1980	76.02	39.20	-0.41	-0.92	-0.54	-2.29
1981	70.29	36.02	-5.73	-3.18	-7.54	-8.11
1982	70.49	33.17	0.20	2.85	0.28	-7.91
1983	64.64	29.32	-5.85	-3.85	-8.30	-11.61
1984	62.10	25.96	-2.54	-3.36	-3.93	-11.46
1985	49.28	18.19	-12.82	-7.77	-20.64	-29.93
1986	47.14	16.00	-2.14	-2.19	-4.34	-12.04
1987	49.43	16.08	2.29	0.08	4.86	0.01
1988	42.83	12.32	-6.60	-3.76	-13.35	-23.38

Source: Annual Vital Statistics Reports published by Central Agency for Public Mobilization and Statistics, Egypt.

A quick inspection of the data suggests that the magnitude of absolute decline in IMR (13 per thousand) between 1984 and 1985 had been surpassed in earlier periods, though large absolute changes in earlier periods occurred before a firm declining trend was established. If we focus on relative decline, the 20 percent change in IMR between 1984 and 1985 is unparalleled for the period considered. The same points hold when we focus on diarrhea associated mortality. The magnitude of absolute change has been surpassed in earlier periods, though the magnitude of the 1984-85 change is the largest from 1975 onwards. The relative change in diarrhea associated mortality is higher between 1984-85 than for any other one year period in the series.Diarrheal mortality change contributed to 61% of the decline in mortality between 1984-85. It should be emphasized that the share of diarrheal decline in the overall change in mortality has surpassed 61% in several earlier years. With the exception of the changes from 1974 to 1975 and from 1982 to 1983 (in which periods diarrhea mortality change was responsible for 82% and 66% of the overall change, respectively), the decline in diarrheal mortality was accompanied by an increase in mortality from other causes. A graphical inspection suggests a change in intercept starting in 1985 and continuing up to 1988, with no change in the speed of decline.

The results of regression discontinuity analysis at the national level are presented in Tables 7 to 9 for different dependent variables (IMR, post-neonatal mortality, diarrhea associated infant mortality) and for both models (1) and (2), using a forward selection technique. In all applications the regression discontinuity analysis rejects the hypothesis of no change in intercept and does not reject the hypothesis of no change in slope. Thus it seems that, from 1985 onwards, infant mortality rates in Egypt moved to a lower base (a change in the constant in the models) keeping the same rate of annual change (no change in the slopes of the relationships) in operation since 1975. The analysis estimates an average decline in IMR, post-neonatal mortality and diarrhea associated infant mortality following NCDDP activities of around eight, nine and seven percent respectively. The change is significantly different from what could have occurred by chance based on time series information from 1975 up to 1984. Table 10 summarizes the expected level of mortality (based on earlier trends) and the estimated new level after smoothing out erratic variations.

The analysis so far has revealed that from 1985 onwards a certain unexpected absolute decline has occurred in infant mortality, particularly diarrhea associated mortality. The level of the decline is consistent with to what would have been expected given the levels of current ORS utilization in Egypt, if the use were of very high quality (general high level and efficient utilization of ORS, at least insofar as utilization for children who would otherwise have died is concerned). However, the estimated impact is much higher than what would have been anticipated based on the few available pieces of information on quality of use.

Table 7

MODEL 1: IMR = a + bt + cp					
VARIABLES IN THE EQUATION					
VARIABLE	B	SE B	Beta	T	Sig T
PROJECT (p)	-8.18560	2.61282	-0.24814	-3.133	.0095
TIME (t)	-2.88320	0.29281	-0.77991	-9.847	.0000
(CONSTANT)	91.39560	1.82859		49.981	.0000
MODEL 2: IMR = a + bt +cp + d(pt)					
VARIABLES IN THE EQUATION					
VARIABLE	B	SE B	Beta	T	Sig T
INTERACTION (pt)	1.24855	1.26277	0.47575	0.989	.3461
TIME (t)	-2.95455	0.30186	-0.79921	-9.788	.0000
PROJECT (p)	-23.29300	15.50170	-0.70611	-1.503	.1638
(CONSTANT)	91.78800	1.87298		49.006	.0000

t: time, 1975 = 1, 1976 = 2, ... 1988 = 14

p: project effect
less or equal 1984 = 0
1985 onwards = 1

Table 8

MODEL 1: POST NEO MORTALITY = a + bt + cp					
VARIABLES IN THE EQUATION					
VARIABLE	B	SE B	Beta	T	Sig T
PROJECT (p)	-9.21440	2.21068	-0.29523	-4.168	.0016
TIME (t)	-2.59051	0.24774	-0.74064	-10.456	.0000
(CONSTANT)	76.07583	1.54715		49.171	.0000
MODEL 2: POST NEW MORTALITY = a + bt +cp + d(pt)					
VARIABLES IN THE EQUATION					
VARIABLE	B	SE B	Beta	T	Sig T
INTERACTION (pt)	0.61145	1.10260	0.24626	0.555	.5914
TIME (t)	-2.62545	0.26357	-0.75063	-9.961	.0000
PROJECT (p)	-16.61300	13.53545	-0.53229	-1.227	.2478
(CONSTANT)	76.26800	1.63541		46.635	.0000

t: time, 1975 = 1, 1976 = 2, ... 1988 = 14

p: project effect
less or equal 1984 = 0
1985 onwards = 1

Table 9

MODEL 1: DIARRHEAL ASSOCIATED INFANT MORTALITY = a + bt + cp					
VARIABLES IN THE EQUATION					
VARIABLE	B	SE B	Beta	T	Sig T
PROJECT (p)	-7.35421	1.70230	-0.33425	-4.320	.0025
TIME (t)	-2.07489	0.22777	-0.70481	-9.110	.0000
(CONSTANT)	48.93786	1.62204		30.171	.0000
MODEL 2: DIARRHEAL ASSOCIATED INFANT MORTALITY = a + bt + cp					
VARIABLES IN THE EQUATION					
VARIABLE	B	SE B	Beta	T	Sig T
INTERACTION (pt)	0.35562	0.82008	0.20331	0.434	.6776
TIME (t)	-2.10862	0.25257	-0.71627	-8.349	.0000
PROJECT (p)	-11.59952	9.95318	-0.52720	-1.165	.2820
(CONSTANT)	49.15952	1.78592		27.526	.0000

t: time, 1975 = 1, 1976 = 2, ... 1988 = 14
p: project effect
less or equal 1984 = 0
1985 onwards = 1

Table 10. Summary of expected (based on earlier trends) and estimated (based on fitted model) measures of mortality

	Year	Expected	Estimated	Relative Difference %	Absolute Difference
INFANT MORTALITY					
	1985	59.68	51.50	13.70	8.18
	1986	56.79	48.61	14.40	
	1987	53.91	45.73	15.10	
	1988	51.03	42.85	16.00	
DIARRHEA ASSOCIATED INFANT MORTALITY	1985	26.11	18.76	28.15	7.35
	1986	24.05	16.68	30.57	
	1987	21.96	14.61	33.46	
	1988	19.89	12.54	36.95	
POST-NEONATAL MORTALITY	1985	47.58	38.37	19.37	9.21
	1986	44.99	35.78	20.48	
	1987	42.40	33.18	21.73	
	1988	39.81	30.59	23.15	

The question then arises of whether this unexpectedly large change can be attributed to NCDDP activities. Detailed information on changes in other macro factors operating in Egypt are unavailable to us at the moment. The general feeling is that, apart from other health campaigns, no sudden major change occurred in determining forces. Other health campaigns, particularly the Expanded Program for Immunization (EPI) program, are believed to have considerably improved immunization[29] practices in Egypt. However, immunization campaigns did not start before 1986, and the benefits of measles vaccination (as one component of EPI) are expected at ages beyond nine months. Following 1986, the change in mortality might have occurred due to the interaction of a multitude of determining forces.

The fact that the decline in mortality occurred in 1985 is the only piece of evidence in favor of NCDDP. The trend post 1985 is quite puzzling: the lack of increase in the speed of decline implies either that increased vaccination levels did not translate into mortality reductions or that NCDDP effects are decreasing over time. However, in the absence of reasonable justification for the change in mortality between 1984 and 1985, and in spite of lack of convincing evidence of the mechanisms operating, there is no basis to refute the claim that NCDDP activities are responsible for such a change. Thus the final conclusion drawn is that an average decline of around eight per thousand in infant mortality can be attributed to NCDDP activities.

The fact that the logic of disproof rather than proof is the basis of our conclusions in favour of NCDDP strongly indicates the need to perform more analysis attempting to document clearly with supporting evidence the mechanisms that are operating.

SUMMARY AND DISCUSSION

The previous analysis illustrated that, in spite of the seemingly simple conceptualization of the role of ORT in reducing mortality, a great deal of complexity is involved in attempting to estimate the potential demographic impact of ORT. This complexity arises in part from the different combinations of actions that may constitute an ORT program. The potential of an ORT intervention is strongly linked to the configuration of treatments adopted which in turn influence the resulting health status of individuals. The implicit curative conceptualization of the ORT intervention in Egypt, the weak state of information on the epidemiology of diarrhea, and the lack of supportive evidence on changes in health status of children cured from dehydration suggest the need for greater care in anticipating the potential of ORT. An upper ceiling for the potential impact of ORT in Egypt is a 25% reduction in IMR.

Despite marked improvements in knowledge, data on ORT practice suggest that the full potential of NCDDP, even in its simplest curative route, has not been achieved. The national estimate of ORS utilization during last episode is only around 30%. Assuming a higher level of ORS utilization (42%) and allowing for differential treatments by type of episodes, the maximum expected reduction in infant mortality is reduced to 19%. Furthermore, the available ethnographic studies suggest a low quality of utilization which, in turn, greatly reduces the expected mortality impact of ORS. The infant mortality and diarrhea associated mortality following the project are lower by around eight and seven per thousand respectively than the level expected to prevail assuming the continuation of the mortality trend that existed prior to the project. Following the project, the mortality measures exhibit the same speed of decline as before the project, but at a new, lower level. The sizes of the changes in infant mortality between pre- and post- project periods are statistically significant (unlikely to have occurred by random chance). The changes are also larger than would be expected from the data on quality of use. Other routes of impact may be operating, particularly in relation to feeding during diarrheal episodes, but available data do not allow this point to be investigated.

There is no evidence that major changes in macro forces - other than NCDDP activities - occurred during 1985. However, from 1986 onwards other health campaigns have operated and the Expanded Program for Immunization reported marked increases in immunization coverage[29].

Within the limitations of current information, NCDDP activities appear to be responsible for the change in mortality from 1984 to 1985. Post 1985, as other large scale interventions have come into existence, the attribution of causality is more complex. The fact that the causality attribution is largely based on the change in mortality in one time period (1984-85) and the weak conceptualization of and information on the implementation side indicate the need for more supportive evidence of the positive role of NCDDP.

In discussing the success of ORT intervention in Egypt, it is important to keep in mind the level of change in mortality and that there is still unmet potential for this program. A better appreciation of the constraints involved in effective use of the technology and a wise choice of configuration of actions adopted by the intervention could greatly enhance its impact. There is also a need realistically to decide the potential of other interventions, on the basis of their cost effectiveness. In doing so, it is important to remember that the utilization of infant or child mortality as outcome measures biases the conclusions drawn. Measures of healthy life must be brought to the forefront.

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